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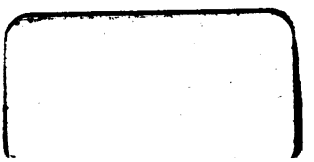

A PLUMBING CATECHISM

OR

THE THEORY AND PRACTICE OF PLUMBING DESIGN

IN

QUESTION AND ANSWER

BY

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PUBLISHED BY
DOMESTIC ENGINEERING
58-64 N. Jefferson St, Chicago
1906

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BY
CHARLES B BALL

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PREFACE

IT has been the purpose of the authors in compiling this book to so formulate the basic principles of plumbing design and practice as to crystallize the knowledge of the skilled plumber and provide to the non-technical reader a source of information on this subject as free as possible from the puzzling set phrases of the craft.

Recognizing the fact that manual skill in the practice of the art may not be acquired from the printed page, the discussion of matters relating solely to handicraft, such as joint wiping, lead burning, etc., purposely has been omitted.

To adapt the book to the needs of those who have occasion to examine plumbers as to their competency the Socratic method of question and answer, having manifest advantages, has been chosen.

Specific criticism of any answers here given will be welcomed.

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A PLUMBING CATECHISM

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THEORY AND PRACTICE OF PLUMBING DESIGN

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QUESTION AND ANSWER.

PLUMBING FIXTURES.

What is a plumbing fixture?

A plumbing fixture is a fixed sanitary appliance provided with a water supply and having a sewer connected waste. This definition will include as fixtures, besides water closets, sinks, etc., refrigerators, bar sinks and dentists rotary cuspidors.

It will exclude condensing tanks and exhaust heads, floor and area drains, unless the latter are provided, as is sometimes done, with a constant water supply.

What considerations should control the choice of plumbing fixtures?

Plumbing fixtures should be selected with due regard to their simplicity, efficiency, cleanliness, durability and relative cost.

(a) Simplicity. Complicated mechanism and intricate form are out of place. The design of valves and plugs, supports and connections as well as the fixture itself, must be plain and simple.

(b) Efficiency. A fixture must adequately serve the purpose for which it is designed. It must, for example, provide the water quickly and must empty promptly and completely. Its trap must form a sufficient and permanent barrier to the entrance of sewer air.

(c) Cleanliness. It is of the highest importance that the fixture be so constructed that so far as possible it will cleanse itself and that any remaining filth may be easily removed. To this end the surfaces must be of a smooth and impervious material to which the wastes do not readily adhere. The interior of the fixture must be free from sharp angles or corners in which filth may find lodgment and its exterior without unnecessary ornamentation. The flushing water must be applied to such points and with such velocity as to effectually scour off and carry away the foul matters.

(d) Durability. It is obvious that the permanence of the fixture is of prime importance.

(e) Relative Cost. Low first cost is often mistaken economy, as frequency of repair and ultimate deterioration will more than offset the initial saving in the purchase of cheap plumbing materials.

Why is the enclosing of plumbing fixtures with woodwork prohibited?

The use of fixtures which do not require to be enclosed avoids the nuisance of (a) a water-soaked and foul wood casing; (b) the presence of a damp, unventilated air space; (c) a natural breeding place for vermin and secures (d) convenience of access for cleaning or repair; (e) a better grade of workmanship because exposed; (f) the immediate discovery of defects or leakage.

Is a safe lining under a fixture necessary?

The practice of providing lead safes under water closets, tubs and basins has become obsolete owing to the improvement of the types of fixtures, the greater security of modern connections on account of better workmanship and improved form and a greater appreciation of open plumbing.

LAVATORIES.

What materials are ordinarily used in the construction of lavatories?

The older types of wash basins (a) were made up of a porcelain bowl and a polished marble slab and back. These materials have been to an extent superseded by (b) solid earthenware or porcelain or (c) cast iron with porcelain enameled surface—materials which permit of the construction in one piece of bowl, slab and back. (d) For wash troughs and sinks soapstone and slate slabs are often used.

What are the merits of the several materials named?

(a) The recognized disadvantages of the marble basin are the two joints between the bowl and the slab and the slab and back. These are rarely water-tight, may be easily broken by shock and offer lodgment for dirt and vermin in the sharp angles. The marble itself is not altogether impermeable and is, as is the bowl, subject to breakage. The marble slab is rarely dished so as to afford proper drainage of any water which may spatter upon it. On the other hand these materials are commercially available, present a good appearance, afford ready opportunity for the attachment of supports and connections and are relatively inexpensive.

(b) The lavatory of solid pottery, having its bowl, slab and back in one piece, avoids the disadvantages of joints and is readily adaptable to the most desirable forms. All sharp corners and angles may be done away

with, generally attractive outlines secured as well as a raised edge and good drainage slopes provided for the slab. The surface of porcelain enamel is nearly an ideal one. To partly offset these advantages are the great weight of solid earthenware, the considerable difficulty of attaching fittings and supports firmly and permanently to the fixture and the greater cost.

(c) Wash bowls of cast iron possess great adaptability in form to the required use and avoid the disadvantage of joints in the fixture. Some of the forms now manufactured are of exceptionally pleasing design. The weight is not excessive and the cost relatively low. The surface of baked enamel is durable and may be readily kept clean, but will not resist the action of abrasive cleaning materials, which should consequently never be used on its surface. The edges and corners of the enameled surface are liable to be chipped and broken through careless handling while being set up.

(d) Washing facilities for men in barracks or factories are provided by wash sinks or troughs. The rounded corners afforded by the use of cast iron as a material can be kept cleaner than the square corners of slate or soapstone sinks. In any material the trough which provides wash water for the common use of a number of persons is undesirable and unsanitary and is justified only by exceptional scarcity of water.

What are the ordinary types of supply fittings for lavatories?

The older form of basin cock has been largely superseded by improved models designed with a nozzle close to and projecting only slightly over the edge of the bowl and therefore much less in the way. A combination supply having a mixing chamber and central outlet is desir-

able and often used. The type of valve may be the ordinary compression, the Fuller or the self-closing. The self-closing faucet is the preferable type for the reason that it prevents waste of water. This type of faucet is not adapted to use on water pressure in excess of 100 pounds because of the liability of water hammer due to the sudden shutting off of the water. Lever handles give a more convenient control of the flow of water than do cross or wheel handles.

What are the common types of lavatory overflows?

The common types of inaccessible overflow passages formerly in use have been superseded to a considerable extent by designs in which the overflow is readily accessible for cleaning. The common types of overflows are:

(a) The ordinary bowl with an outlet horn to which a lead pipe is attached. This retains a larger quantity of decomposing matter than any other type.

(b) An overflow passage of porcelain or cast iron integral with and conforming to the curve of the bowl. The interior surface of these integral overflows is likely to be unfinished and somewhat rough.

(c) The standing overflow consisting of a tall plug with an open end. The presence of the overflow tube is objectionable unless the rear portion of the basin is recessed, so as to provide a suitable space in which the tube may be placed. On the other hand the simplicity of this type of overflow commends it.

(d) The concealed standpipe overflow in which the waste water is held at a level with that in the basin. If properly designed this is readily accessible for cleaning, but the standpipe is seldom removed for the purpose of cleaning, consequently the water in the basin is subject to contamination from the filth in the connecting overflow.

(e) A fifth and preferable type is integral with the bowl, straight or nearly so, and of sufficient size to be readily cleaned with a cloth or swab.

What are the usual methods of control for the waste outlets of lavatories?

Numerous patents have been granted for basin valves, most of which cover intricate mechanism having little real value. The simple plug and chain continue in many instances to be used, owing to their cheapness, notwithstanding the objection to the chain as a filth retainer.

The standing waste plug is simple and cleanly, but must be seated on a carefully ground seat or a rubber washer.

The concealed standpipe waste is liable to become foul and its cleaning to be neglected.

A short removable metal plug raised and lowered by a revolving lever, having a handle above the slab and entering the waste chamber through a simple stuffing box, is a common and desirable form of outlet valve.

KITCHEN SINKS.

What materials are ordinarily used in the construction of kitchen sinks?

The kitchen or scullery sink is most frequently made of:

(a) Cast iron, either with plain, painted, galvanized or porcelain enameled interior surface.

The uncoated or black surface can, with considerable care, be kept fairly clean, but does not ordinarily receive the attention necessary to keep it in a sanitary condition.

A painted surface is of doubtful utility when new and seldom receives the frequent repainting which it demands. Moreover the grease readily adheres to it.

A galvanized or zinc-coated surface presents a clean appearance, is relatively smooth, and if the coating is heavy is quite durable.

Enameled kitchen sinks are obtainable in great variety, and of these the white or porcelain enameled sinks are especially well adapted to their intended use, offering a hard and fairly durable surface, subject, however, to the abrading effect of hard usage. The white color obviously tends to cleanliness. The cost is approximately twice that of painted or galvanized sinks.

(b) Wrought or pressed steel sinks are gaining in use. When first put on the market this type of sink ordinarily was not heavy enough to retain an enameled coating or to withstand hard usage. Those now available have the advantage of lightness but are sufficiently stiff to retain an enameled finish and to resist ordinary shocks.

In general the iron and steel sinks are of exceptionally desirable form, having roll rims, curved corners and a bottom so graded to the outlet as to afford proper drainage.

(c) Crockery and porcelain sinks are made in numerous suitable shapes and the price is not now prohibitive. The better grades have a superior glazed surface, are readily kept clean and will endure hard usage. The disadvantages are the heavy weight of this material and the possibility of fracture in shipping and handling.

(d) Natural stones, such as slate and soapstone, constitute an available material for sinks. The denser grades are non-absorbent. The numerous joints and the sharp angles of the corners are objectionable.

(e) In the present state of the plumbing art wood ought never to be used as a material for kitchen sinks. With the best of care it is constantly water soaked, resulting in its rapid decay. The supposed safeguard by the use of wood against breakage of dishes is overestimated. The use of a rubber mat will accomplish the same result with a distinct sanitary advantage.

Is it desirable to provide means for closing the waste outlet of kitchen sinks?

The outlet of a kitchen sink is usually provided with a strainer only, with no means of controlling the outflow of water. It is, however, a distinct advantage to provide for closing the outlet either by means of a standing overflow with ground stopper or by a perforated disc strainer like a spice box top, which may be revolved, to close the holes. Such an arrangement allows hot water to be retained in the sink for cleaning and by its sudden release to effect a more thorough cleansing of the trap. Some

housewives prefer to use the sink in place of a dish pan for washing dishes and kitchen utensils.

What characteristics are required in a sink strainer?

A sink strainer should be made of brass, should be of ample size and have large openings to allow of quickly emptying the sink. For obvious reasons the strainer should be firmly secured in place so that it cannot readily be removed without the use of tools.

What principles should govern the design of the sink wastes and connections?

The 2-inch waste and trap frequently used, and required in some cities, is much too large for ordinary kitchen sinks and affords greater opportunity for accumulations of grease. It has been shown by experiment that with a well arranged funnel-shaped outlet a smaller waste —even as small as 1-inch diameter—is adequate and is much less liable to obstruction. It is equally important that the branch into which the waste connects, in order to secure the proper scouring effect, should not exceed 2 inches diameter. The prevalent opinion that this branch must be of large size to avoid obstruction is a mistaken one.

In what cases is a grease trap necessary for kitchen sinks?

The main necessity for a grease trap occurs in places such as hotel or restaurant kitchens where the fixture is in practically continuous use for the discharge of very greasy wastes. The waste and trap located near the sink are kept so warm by the constant flow of hot water that the grease does not coagulate until it reaches a distant and inaccessible portion of the waste pipe, where it is likely to accumulate so as to cause obstruction.

The usual difficulty with a kitchen sink infrequently used is that a quantity of melted fat is poured upon the standing water in the trap which is cool enough to cause the grease to harden on the surface, forming a layer often not more than an eighth of an inch thick but sufficient effectually to stop the fixture waste. The easiest remedy for this condition is to allow the hot faucet to flow when melted fat is poured into the sink.

What is a frequent cause of failure in the operation of a grease trap attached to a hotel or restaurant sink?

It sometimes happens that the constant flow from a sink is sufficient to keep the waste matter in the grease trap so hot that the grease does not harden, in which case it will flow through the trap with little interruption. To be effective a grease trap for such a situation should be provided with a water jacket through which flows the cold water supply, preferably that which furnishes water to the hot water boiler.

To what objections is the grease trap liable from a sanitary point of view?

(a) The use of a grease trap violates the accepted principle that foul matter should be removed from the plumbing system without any delay.

(b) Very few grease traps are so designed that they may be sealed securely and permanently so as to be gas-tight after being opened for cleaning by inexperienced persons.

BATH TUBS.

What materials are ordinarily used in the construction of bath tubs?

(a) Wood, lined with sheet metal. (b) Sheet steel lined with copper. (c) Cast iron, painted or enameled. (d) Solid porcelain.

What are the merits of the several materials named?

(a) The objections to a wooden tub lined with metal, by reason of the absorptive nature of the wood and the liability of the lining to leakage are so well recognized that a tub of this kind should never be installed.

(b) Bath tubs formed of sheet steel lined with tinned sheet copper, usually with a putty layer between, and finished with a wooden rim constitute the so-called "steel clad" tubs. This fixture is light and cheap, has a good form, can be supported on legs and is reasonably clean. Its disadvantages are the absorptive wood rim and the liability of the copper lining to become worn or be punctured.

(c) Cast iron is a very common and readily available material for bath tubs. If the interior surface is painted dirt adheres to it and it is not cleanly. The far better and more common coating is a vitreous enamel which is smooth and impervious and if properly compounded and baked is not likely to crack. Abrasive scouring soaps, however, may cause damage to the enamel, resulting in a rough surface to which dirt may adhere.

(d) Porcelain tubs having a fireclay body protected with a heavy porcelain enamel have few disadvantages.

They are, however, heavy, liable to fracture and relatively expensive.

What is the common type of supply fittings for bath tubs?

The hot and cold water supplies may enter the bath through separate faucets but are usually delivered through a combination bath cock, consisting of a single discharge nozzle to which the hot and cold supplies are joined. Any method of supplying the water at or near the bottom of the tub through a submerged bell is unsafe because of the possibility that foul water may be drawn back into the supply system under certain conditions. The supply pipe and valves must be of ample size in order to provide for the speedy filling of the fixture.

What are the three common types of bath tub waste connections?

The most common outlet connection for a bath tub is (a) a combined waste and overflow on the outside of the tub. These have largely supplanted (b) the ordinary waste and plug; (c) the standing overflow and waste, consisting of an open ended tube which can be placed in the waste coupling. Care must be taken to see that the overflow is of sufficient capacity to carry the largest volume of water which can come in through the supply cocks. The waste itself should be large enough to empty the tub quickly.

What is the purpose of a sitz or seat bath?

The characteristic form of this fixture, having the back higher than the front, and its relatively small size render it convenient for use as a foot bath, children's bath, etc., as well as for its distinctive use for women. The connections are the same as for a bath tub with the

exception that the combined hot and cold water supplies have a hooded inlet on one side, near the bottom of the tub. Where desired this fixture may be made with a spray designed to play upon the back when one is seated in the tub, giving a local tonic often prescribed by physicians.

What inherent advantages has a shower over other bath fixtures?

The growing appreciation of the shower or rain bath is due to the recognition of its hygienic features on account of the use of running water and of its stimulating effect, due to the impact of the water jets upon the body. The shower bath is especially desirable where bathing facilities are so limited as to compel several persons to use the same bath. The modern type of installation with a receptor or receiving basin, does away with the inconvenience of the old method of installation, which required a water-tight floor depressed to slope toward a floor drain.

LAUNDRY TUBS.

What materials are ordinarily used in the construction of laundry tubs?

(a) Wood. Not now frequently used because of recognized objections; wood decays rapidly when alternately wetted and dried.

(b) Cement. A well-designed and metal-reinforced cement tub, made from a rich mixture of good cement, and well finished, possesses many of the advantages of the more expensive materials. The material can be so molded as to avoid entirely the sharp interior angles which are objectionable in any plumbing fixtures. Cement tubs carelessly made from a poor mixture have rough surfaces, are fragile and absorbent, and cast discredit on this type of tub.

(c) Natural stone. The natural stones, slate and soapstone, have the advantages that they are practically nonabsorbent, are susceptible of a good polish, are available and cheap and may be shipped knocked down after manufacture. The poorer qualities of natural stone are friable and absorbent and, therefore, do not give satisfaction. The limitations imposed by the slab form compel sharp interior angles and corners which are not easily cleaned. The use of a poor quality of cement for jointing often results in leakage.

(d) Cast iron. The more desirable forms and more durable coatings resulting from improved processes in the

manufacture of cast iron enameled ware have brought fixtures of this material into general favor.

(e) Solid earthenware. Laundry tubs of this material are attractive and durable. The interior surfaces are hard and smooth and the corners and edges well rounded. The greater cost and heavy weight are the practical drawbacks to the extended use of these tubs.

What consideration should control the type and position of laundry tub connections?

The supply lines should be of ample size—at least ¾-inch. To avoid danger of striking the head, faucets should be located well toward the ends of the fixture, and should not project far over the edge of the tub. The central space should not be obstructed by soap cups or plug rings on which clothes may be caught and torn.

The outlet and strainer should be especially designed to be of capacity to fill a 1½-inch waste pipe, which in the majority of cases should be the maximum size.

By reason of the infrequent use of the fixture, and increased liability to evaporation, the trap should have a seal of not less than 2 inches. Through the accumulation of ravelings from the clothes the danger of trap siphonage by capillarity is great and the use of some form of trap less subject to loss of seal in this way than the ordinary S or P trap is recommended.

Too little attention is paid to the providing of adequate and well secured floor and wall supports in view of the weight of the fixtures and the water and clothes that they contain as well as the strains to which they are subject from the operation of clothes wringers, etc.

SLOP SINKS.

What materials are ordinarily used in the construction of slop sinks?

(a) Cast iron, usually enameled.

(b) Solid earthenware.

What considerations govern the design of slop sinks?

(a) Ample size. The fixture must be sufficiently large to allow of the reception of a pailful of slops without special care to avoid splashing.

(b) Sharp interior angles must be avoided, in order that the fixture may be readily cleaned.

(c) Every slop sink should be provided with a flushing rim in order to secure adequate wetting of the surface before slops are thrown in and the effectual washing of the fixture after use.

(d) The strainer and outlet passages must be large, the grating must have coarse openings and be easily removable for cleaning.

(e) The fixture should be placed at quite a distance from the wall in preference to supplying a splash back.

(f) The slop sink should be provided with both hot and cold supply, preferably through a combination faucet so strong and well braced as safely to support a slop bucket in process of filling. This will avoid damage to the enameled surface in case a metal bucket is used.

What type of trap is generally used for slop sinks?

The most usual trap fitted to slop sinks is an S trap designed with flanges so as to be used as a standard for

the fixture. This form has been chosen largely as a result of the large size of the outlet, usually three inches.

What disadvantages are inherent in the trap standard?

(a) The floor joint—a joint difficult to construct and maintain.

(b) Interior cast partitions, the position of which is not evident on the outside.

URINALS.

What are the four most common types of urinal construction?

(a) The most common type of urinal consists of a porcelain bowl, usually provided with a flushing rim and in some cases having a porcelain trap integral with the bowl. The advantage of this type consists in superior material, a relatively small amount of fouling surface, which is of a character which is easily kept clean and of a form adapted to ready flushing. The principal disadvantages are the liability to clogging, the expense, especially in view of the fact that a stall setting is required, and the liability to fracture when carelessly used.

(b) The simple trough type is very common. It may consist of a zinc-lined, wooden trough, which almost invariably constitutes a decided nuisance, of slate or of earthenware, the latter not common in this country, or of cast iron, usually enameled. Trough urinals are usually flushed by means of a perforated pipe at the back. The enamel surface is of a fairly satisfactory character for this use. The trough, however, presents a large fouling surface so arranged that it cannot be effectively flushed. The relative cheapness of this fixture results from the fact that it is usually installed without floor slabs or stalls.

(c) Natural stone slabs have been for a long time a common material for urinal fixtures as well as for stalls for urinals. The essential parts consist of a back slab

placed over a groove or trough in the floor slab, and provided with a perforated pipe or jet flush.

Much study has been given to improving the design of this form of fixture and as now constructed with toothed overflow flush, inclined back slab, standing water in the trough, concealed outlet and ventilating chamber, it is entitled to rank as a high-grade plumbing fixture.

(d) Glass offers an attractive material for slab construction, but its use has not heretofore been satisfactory, as its surface has been attacked by the ammonia salts. It is claimed that glass now made especially for this purpose successfully resists this corrosive action.

(e) An adaptation of the slab form in pottery design, in which the back, sides and bottom are made in one piece of earthenware, offers the advantages of rounded corners, absence of joints and an excellent surface.

(f) There has recently come into use an individual urinal consisting of a hopper-like pedestal having integral bowl and trap. It is a well-designed and convenient fixture, but relatively expensive.

What kinds of flushing apparatus are provided for urinals?

Inasmuch as a urinal without an adequate flush constitutes a marked nuisance, much attention has been devoted to the methods of supplying water to this fixture.

(a) The perforated or slit pipe applied to a slab is a simple but ineffective method of flushing the urinal surface, as it fails to distribute the water evenly.

(b) Numerous rose and spray devices have been used for this purpose with varying results. In general any small slit or other orifice is objectionable on account of liability to clogging.

(c) The overflow from a trough along the top of a fixture through notches like saw teeth in the top of the slab secures the spreading of the water in a thin, uniform film over the entire surface of the slab. The distribution of the flow may be adjusted by filing the notches.

(d) Waste of water is liable to result from any constant flow apparatus owing to the use of a larger quantity of water than necessary and the possible failure to turn off the supply over night and during holidays.

(e) Any periodic flushing is to a degree unsatisfactory because foul matters become partially dried and adhere to the surface between the flushing periods so that they are not entirely removed by the subsequent flushing.

(f) Fairly satisfactory results are obtained by the use of a general tank, the flow from which to each fixture is controlled by a well designed measuring valve.

(g) Whatever the type of design or character of the surface, it is impossible to keep a urinal in clean condition without frequent and thorough cleaning with soap and water, for the reason that the foul matters spatter over and adhere to angles and corners which cannot be cleaned by the flushing, however applied.

What important general considerations must be kept in mind in connection with the design and flushing of urinals?

(a) A well designed urinal, as indeed all other plumbing fixtures, should have the most limited amount of fouling surface consistent with convenient use. It is of prime necessity that non-porous surfaces of the best character be provided for the floor and walls surrounding any urinal fixture, and that metal trimmings be so placed as not to be exposed to spattering. The type of design will,

however, be governed by the frequency of use of the fixture.

(b) The immediate dilution of the urine in a body of standing water lessens the strength of the salts in solution, and so decreases the liability to nuisance in any type of fixture.

(c) Of the types of flush applied to bowl urinals through the flushing rim the simple direct connected valve to be operated by the user, is unsatisfactory because the small size of the connecting pipe and low city pressure often result in an insufficient flushing of the urinal surface, even when the operation of the valve is not overlooked by the user. An individual chain-operated tank flush overcomes the lack of pressure and supplies a larger flush connection, but may be ineffective through lack of use.

(d) Automatic individual tanks operated at intervals by various means, such as the tipping of a receptacle overbalanced when filled, or the periodic discharge of a siphon, etc., are improved types. The operation of a valve by the opening and closing of the stall door or by a tread on the stall platform is reasonably effective.

WATER CLOSETS.

What are the essentials of a good water closet?

(a) The body must be strong and impermeable. The interior surface must be as smooth as possible, and of a character not injuriously affected by changes of temperature or by exposure to the waste matters which come in contact with it.

(b) The form should be simple, compact and without angles or corners. The bowl, in order to facilitate flushing, should have vertical sides and should retain sufficient standing water to receive and deodorize the waste matter.

(c) The operation of the flushing apparatus should be accomplished by a simple mechanism and the flushing should, with a minimum amount of water, immediately remove all waste matter without spattering, and in so doing should effectually scour all the closet surfaces. Noiseless operation is not sufficiently appreciated. The trap should have a deep seat and should be conveniently accessible. The closet bowl itself should be designed without moving parts. The soil pipe and flushing connections should be simple, permanently tight and should permit of ready setting and disconnecting.

Name the principal disapproved types of water closets and briefly describe their characteristics.

The types of disapproved water closets which should no longer be installed, but examples of which are still found in use are:

(a) The pan closet consists of a closet bowl, the outlet of which is closed at the bottom by a hinged saucer-shaped pan, controlled by a weighted lever and handle and emptying into an outer jacket or receiver. This fixture was originally constructed with the receiver connected direct to the soil pipe, but the later types were provided with a trap, sometimes vented. The main objection to the pan closet arises from the invariably foul condition of the receiver, a large portion of the surface of which is never flushed. Some minor objections are the inefficiency of the water seal in the pan, the possibility of the contamination of the water supply through the direct connection and the presence of surrounding woodwork.

(b) The plunger closet, by no means uncommon in certain localities, consists of a bowl with an auxiliary side chamber in which the water stands at the same level as that in the bowl until the fixture is discharged. The outlet in the bottom of the chamber is closed by a heavily weighted valve or plunger, which must be lifted to discharge the fixture. While to casual observation the fixture does not appear objectionable, it is so by reason of the coated surfaces of the chamber and valve, which are invariably foul. These closets were usually directly connected to the water supply pipe and the inadequate provisions for overflow rendered them especially liable to give trouble from this cause.

(c) The long hopper closet is still sometimes necessarily installed in situations where the fixture is exposed to frost, but its maintenance is inexcusable within properly heated buildings. It has the merit of simplicity, consisting only of a conical bowl placed over a trap below the floor. The objections to this fixture consist in the large amount of fouling surface, poorly flushed, a foul

trap not accessible for cleaning and an unsatisfactory connection between the bowl and the trap. All of these objections apply with special force to the offset hopper closet which is used in some localities to replace pan closets without removing the trap below the floor.

(d) The latrine type consists of a long open trough usually having a small quantity of water in the bottom, and above which are placed a number of closet seats. The flushing is accomplished by the intermittent operation of a tank with a siphon valve, sometimes partly discharged through a perforated pipe extending along the sides of the trough. The manifest objections to this fixture are the communication of odors from one seat to those adjoining, the large amount of fouling surface, a considerable portion of which is alternately wet and dried, and the insufficiency of the flushing.

What are the current types of water closets?

(a) The short hopper water closet, which was originally constructed in two parts, an S trap and a bowl clamped together has been for some years constructed in one piece, either of earthenware or of cast iron, and is therefore termed a combination water closet. The principal advantages of the short hopper closet are its simplicity and cheapness. It has only a small exposed area of standing water and the surface of the bowl is consequently exposed to fouling, although this defect has been overcome to a degree in some of the best designs.

(b) The washout closet may be known by its characteristic exposed weir or dam, which retains a shallow pool of water in the bowl. The position of this dam and of the outlet may be either at the front or rear of the closet. The limitation necessary in the design of the bowl and

the fact that the flushing water must be mainly introduced opposite to the outlet in order to carry the contents over the dam, result in the ineffective scouring of a considerable portion of the surface.

(c) The washdown closet has numerous forms, but may be considered either as a modified type of short hopper combined closet or as a washout closet having a concealed weir. The intent of the modifications in form is to secure a considerable depth of seal without increasing the amount of standing water, while so disposing the water in the bowl as to present a large horizontal area, decrease the dry fouling surface and still secure an effective flush.

(d) The siphon closet consists essentially of a porcelain pipe, constituting the long leg of a siphon and the central inclined passage from the bottom of the trap to the top of the weir or dam, forming the short leg, which is submerged in the water held in the bowl. The siphonic action of the closet depends upon the sudden discharge of a sufficient amount of water into the long leg of the siphon to accomplish by its fall the rarefaction of the air therein, so that the water in the bowl impelled by the atmospheric pressure rushes through the short leg and in turn through the outlet leg till the bowl is emptied.

The efficiency of the siphon closet depends upon the relative length and size of the long and short legs. Siphon closets are often designed with too little depth of seal and with crooked and contracted outlet passages. On account of the complications of form, requiring many small pieces which must be fitted together exactly and the consequent greater difficulty of firing, the cost of manufacture is increased.

(e) The siphon jet closet is one in which the inertia of the standing water in the short leg of the siphon is

overcome not alone by the effect of the water from the flushing rim, but also by the operation of a stream or jet of water introduced at the bottom of the fixture. This closet requires less standing water in the bowl because of the promptness with which the jet induces the siphonic action. Without the jet the siphonic action does not take place until after the water from the flushing rim has set in motion the whole body of standing water. The jet may be so placed as to remove immediately from the bowl the remnants of the soil, etc., which have a tendency to lodge in the eddies of the outgoing stream.

WATER CLOSET FLUSHING APPARATUS.

Name the principal methods employed for the flushing of water closets?

(a) The simple valve directly connected to the water service. This may be controlled by a lever handle, or by a self-closing spring valve, or by a seat actuated mechanism. In exposed locations the valve is usually set below the frost line and should be accessible in a concreted and drained masonry pit.

(b) A measuring valve which, by its automatic action, limits the amount of water supplied at each flush. The delicacy of adjustment of these valves is such that few of them, because of changes of pressure, will operate properly if directly connected. This difficulty is overcome by supplying the valves from a storage tank. Any direct connection of a water closet flush valve to a supply for cooking or drinking purposes is liable, when accidents happen to the system, to contaminate the supply, and is therefore dangerous. Measuring valves connected to a storage tank, the water from which is used for no other purpose, are well adapted for use in buildings having a large number of water closets, especially if these are grouped in a few toilet rooms.

(c) A flush tank or cistern set over the fixture. In the older type this is placed about six feet above the closet. A later type is placed immediately above the closet. To offset the loss of head the low tank is connected to the flushing rim by a pipe of larger size.

(d) A closed tank to which the water is admitted until it ceases to flow because the air pressure in the tank is equal to the pressure upon the city water system. When the pressure on the closet seat is released the valve is closed on the supply side and opened to the closet, so that the flushing water is driven out by the air which has been compressed in the tank. This type of flushing tank offers opportunity for adaptation and development.

What are the characteristics of a good water closet flush tank or cistern?

The characteristics of a good tank apparatus are:

(a) Efficiency in action. The efficiency of the flush depends upon the immediate discharge of a quantity of water and the supplying, after the closet has discharged, of the requisite water to refill the bowl to the proper level.

(b) Simplicity. There are numerous types of tank apparatus which have some part or parts subject to derangement, hence special emphasis is laid upon the advantages of mechanism which has few parts, and those of strong construction.

(c) Noiseless operation is a self-evident advantage.

What are the common types of tank operating mechanism?

(a) The supply inlet to an open flush tank is generally controlled by a ball cock, which shuts off when the cistern is filled.

(b) The most simple type of flushing valve apparatus is that in which the outlet valve is lifted by a lever and chain pull, the amount of water flowing down the flush pipe being controlled by the length of time the lever is depressed.

(c) The various types of siphon cisterns are so designed that the depression of the lever for a moment starts a siphonic action in the outlet pipe. The simplest type consists of a standing outlet tube, covered by a dome or outer tube, the momentary lifting of which induces siphonage. When the siphonic action is started the water continues to flow until the tank is nearly emptied. A small opening near the bottom of the tube causes the siphonic effect gradually to be broken and insures the refilling of the closet bowl.

(d) The float valve tank is a type in which a valve attached to a float so as to be but slightly heavier than the water displaced, after being raised by the action of the lever, remains buoyed up until most of the water has flowed out, when it is gradually returned to its seat. The refill of the closet bowl is accomplished by means of a small siphon which serves also as an overflow.

LOCAL VENTILATION.

What is meant by local or seat ventilation as applied to a water closet?

By local or seat ventilation, distinguished from trap ventilation, is meant a system of vent piping by which the foul odors may pass from the closet bowls to the outer air. The efficiency of operation depends upon the means employed to render the air passing through the vertical flues in such a system warmer and therefore lighter than the air of the toilet room. The air outflow may also be maintained by means of a mechanical blower or exhaust.

What is the principal advantage of local ventilation?

The evident advantage resulting from local ventilation is the immediate removal of foecal odors from the closet before they become diffused throughout the room.

Are there disadvantages incidental to local ventilation?

Three incidental disadvantages are found as a result of seat ventilation.

(a) The complication of the closet bowl construction, which results from the providing of another opening of considerable size, usually 3-inch, through the side of the fixture.

(b) The fact that any additional break or pocket in connection with the bowl enlarges the fouling surface and is likely to afford lodgement to waste matter.

(c) A third connection complicates the work of setting or disconnecting the bowl and, in case of breakage, requires that the fixture be replaced by a closet which is an exact duplicate of the broken one.

FLOOR SLABS.

Is it desirable to use stone floor slabs under water closets?

The use of floor slabs under fixtures where dripping is likely to occur is advantageous for two reasons:

(a) A non-absorptive stone surface does not retain the foul drippings as does a wooden or even a jointed tile surface.

(b) The fixture itself is afforded a firmer and more secure base support.

In general it is not best to provide any outlet connection for the floor slab, as in most situations the amount of dripping is slight and may easily be wiped up with a mop or cloth.

What natural stones are suitable for floor slabs?

Marble, which is most commonly used, depends upon the finish of the surface for its impermeability. This finish deteriorates in time and the porous body of the stone absorbs the foul water to a considerable degree. The best slates are practically non-porous and suitable for this use except for their dark colors. High grade soapstone is easily worked and is impermeable. Its gray color is not a serious objection since dirt on the surface is more noticeable than on the dark colored slates.

In what manner should the surface of a floor slab be countersunk?

The usual method of countersinking a floor slab to a plane surface is of little value. The cut surface should

slope from near the edges to some central point with a pitch sufficient to collect at that point any drippings which may fall upon it. A floor slab having an outlet connection must be not less than one and one-half inches in thickness in order to provide sufficient support beneath the flange of the coupling at the thin point of the stone.

REFRIGERATORS.

In what essentials is a refrigerator or ice box different from any other plumbing fixture?

A refrigerator differs from other fixtures in that it is a receptacle for food supplies and depends wholly for the seal of its trap upon the uncertain and intermittent flow of water from melting ice. For these reasons special precautions are demanded in the method of its connection with the drainage system.

What are the proper constructive precautions to be observed in designing a refrigerator connection?

The refrigerator drip pipe should discharge indirectly over a floor drain, itself provided with an accessible trap having a cleanout screw. The branch waste from this trap should discharge into a vertical line of pipe passing through the roof and having its lower end over a small sink or like fixture, water supplied, and in plain view in a frequented situation. The two disconnections and the two trap seals effectually remove the food in the refrigerator from danger of contamination from the sewer air in the drain.

When a trap is provided under the refrigerator there is little necessity that the lower end of the vertical line be provided with a flap valve, as is sometimes required in local regulations.

The trap immediately under the refrigerator is not required to be vented, unless it is on an unusually long horizontal branch.

On account of the liability of the inlet, traps and waste pipes on a refrigerator line to clogging with sawdust, straw and fungus growth, frequent cleanouts should be provided, and the pipe, if possible, should be exposed throughout its entire length.

WATER SERVICE PIPES.

How should the service pipe be connected with the street main?

A water service pipe should not in any case be rigidly connected with the water main, but some construction allowing for adjustment for settlement and expansion of the main must be introduced. The corporation cock should be inclined above the horizontal axis of the main and if the service pipe is of lead at least six inches of slack should be provided in making the connection. If the pipe is of iron a flexible connection of lead two or three feet long should be used.

What pipe materials are commonly used for this part of the supply system?

The materials most commonly used for service pipe are lead, plain iron, galvanized iron, block tin and tin- and lead-lined.

What are the relative advantages and disadvantages of these materials?

Extra heavy lead pipe is generally used for this purpose. It is durable, has few joints, is not damaged by settlement of the trench and is not very costly. In rare cases, with certain natural waters it is unsafe because of the effects of chemical action. Before being prescribed for use in any given locality experiments should be made to determine the degree of chemical action to which it is subject. With very soft water oxide of lead is formed,

which remains in solution and has harmful effects upon the human system. With water containing free carbonic acid gas, an insoluble coating of lead carbonate is formed on the inside of the pipe in the first few weeks of use, protecting the metal from further corrosion. In general it may be said that with hard water lead pipe may be safely used.

Uncoated iron pipe is cheap, but soon becomes clogged with rust.

Galvanized iron pipe is inexpensive, is easily jointed and readily obtainable, and in localities having light soils, so that it is not corroded on the outside, affords a reasonably satisfactory pipe for this use. In exceptional cases danger may attend the use of galvanized pipe through the formation of zinc compounds.

Block tin pipe is a very desirable material so far as safety is concerned. It is expensive and liable to leak at the joints because the solder with which the joint is made is not homogeneous with the material of the pipe.

Lead-lined and tin-lined lead and iron pipe have come into considerable use in the last few years. These pipes are not jointed with facility, but otherwise possess the combined advantages of the materials of which they are made.

What is the usual size of the water service pipe for an ordinary dwelling?

The ordinary size of service pipe for supplying water to a dwelling is ¾-inch.

How should the lead portion of the service pipe be connected to the iron?

Lead pipe should be joined to iron pipe by the use of a brass solder nipple to which the lead pipe is connected

by means of a wiped solder joint and the iron pipe by means of a screw thread.

Is it desirable to install a stop cock in the service pipe between the house and the street main?

As the corporation cock at the main is usually inaccessible without making an excavation in the street, it is desirable to provide a stop and waste cock, placed in a box on the service pipe at an accessible point, usually near the curb, to provide a means for shutting off the water without entering the building.

Is it permissible to feed a supply pump directly from the street main?

If the building is supplied through a water meter the pump must not be directly connected to the service pipe on account of possible damage to the meter through pulsations of the pump. Some cities require that the pump be fed from an open tank into which the water is discharged before being pumped. The uniform feed and operation of the pump is also assured by this construction.

FIXTURE SUPPLY PIPES.

By what means can a uniform supply of water to all fixtures be secured?

The most necessary means to secure a uniform water supply to all fixtures is to properly proportion the different parts of the supply system. Special care must be taken to provide a good supply to fixtures in frequent use, such as the kitchen sink. In general it may be said that two fixtures should not be supplied from a less size than a ¾-inch pipe and not more than four or five fixtures from an inch pipe. A separate line should be run from the main supply pipe in the cellar if difficulty is experienced with a particular fixture in cases where the pressure is light. Where fixtures on different floors are supplied from the same line, a pipe of ample size must be provided to the lowest fixture.

How should supply pipes be proportioned if the source of supply is a tank located above the highest fixture?

A large size pipe is used at the connection with the tank and the size reduced as branches to the lower fixtures are taken off. It should be noted that the effect of the pressure due to the height of the tank is an advantage to the remote fixtures instead of a disadvantage due to loss of head, as in the case of direct supply. This permits the use of smaller pipe for the fixtures near the end of the line than is customary with direct pressure.

How does the height of a column of water affect the pressure?

The increase of pressure of a standing column of water due to the increase of height is .4335 pounds of pressure to every foot of height without regard to the horizontal dimension of the column in any direction. This may be roughly calculated by allowing three pounds pressure for every seven feet of height.

Can fixture supplies be so arranged that water can be drawn either from the main or from the tank?

It is impracticable on account of the varying pressure in the public mains to design an open-tank system in which the fixtures may be supplied alternately from either source. A system of rising mains can be so arranged with valves that any given floor may be cut out of the direct system temporarily and supplied from the tank, or vice versa, but rather large sizes of pipe are required in this case.

In running supply pipes under an upper floor, what precaution is desirable to protect the ceiling below against leakage?

A box lined with lead or galvanized iron, sloping to a fixed point from which a waste pipe leads to a safe place of discharge will prevent injury to decorated ceilings.

STORAGE TANKS.

What conditions require the use of a tank supply?

In cases where the street pressure is variable or insufficient to supply the fixtures on upper floors constantly a tank must be installed a few feet above the highest fixture to provide for the storage of water.

What are the materials commonly used for tanks?

(a) The most available material is wood, frequently with a sheet metal lining of lead, zinc, tinned copper or thin galvanized iron. For this purpose are also commonly used: (b) Steel or wrought iron plates with riveted joints; (c) cast iron plates with flanged edges bolted together; (d) slate, soapstone and marble slabs are used in some localities where the cost of transportation is not great.

What relative advantages have these various materials?

(a) The wooden tank, unlined, is subject to decay along the line about which the water varies. It cannot be thoroughly cleaned. Lead, zinc, tin and galvanized iron are attacked by some kinds of water and for that reason their use in some localities is prohibited. The galvanized iron is the least objectionable of these. Tinned sheet copper is an expensive but durable and safe sheet lining. (b) A tank made of wrought iron or steel plates should, if possible, be galvanized after completion in order to avoid rust. (c) The same process should be applied to separate cast iron plates before they

are put together. (d) Slate, soapstone and marble are excellent materials for tanks, being durable and easily cleaned.

Has wood any advantage over iron as a material for a tank set in a location exposed to frost?

Since iron conducts the heat of the water rapidly to the outer air, it is a less desirable material than wood for an exposed tank, owing to the liability to rapid freezing. For this reason the protection afforded by a wooden housing about exposed tanks warrants the additional expense.

What precaution should be taken to afford safe supports for a heavy house tank?

A house tank holding a considerable volume of water should be supported upon beams or girders, preferably iron, resting on the house walls independent of the floor joists or partitions, in order to avoid, so far as practicable, the danger from the falling of the tank if the bearings are weakened by fire.

What is a reasonable capacity for a tank for household supply?

If the tank is supplied by direct pressure and filled at night only its capacity should be slightly in excess of the heaviest draught during any twenty-four hours. If the supply is by a house pump the capacity can be somewhat smaller. It is good practice to provide a supply of twenty-five gallons per person.

How may the capacity of a tank be computed?

First find the floor area of the tank in square inches. If the shape be rectangular this will be the product of the length multiplied by the width; if circular the product of

the square of the diameter multiplied by .7854. The product thus obtained, multiplied by the height (in inches) to the surface of the water, and divided by 231 (cubic inches in standard gallon), will give the contents of the tank in gallons.

Name the four essential pipe connections for a house tank.

(a) The supply or inlet; (b) the outlet; (c) the blowoff or cleanout, and (d) the overflow.

At what point should the inlet pipe be connected to the tank?

The inlet pipe to a house tank should be brought in near the top and extended down inside the tank to avoid the noise of splashing. It must not, however, reach near enough to the bottom of the tank to stir up the sediment.

From what point should the outlet pipe be taken?

The outlet pipe may either pass directly through the bottom of the tank, extending up a few inches on the inside, or may be taken from the side a short distance above the bottom. It must not drain the entire contents of the tank.

How should a blowoff or cleanout be arranged, and what is its purpose?

A valved blowoff or emptying pipe must be arranged so as to drain all the water from the tank to allow of the complete removal of deposit from the bottom and thorough cleaning inside. It should be of relatively large size to permit quick emptying in case of fire, avoiding the danger incident to the sudden removal of the supports from such a heavy body of water. When practicable it should discharge upon the roof or into a gutter or open

area. Otherwise it may discharge into a sink or floor drain having a waste pipe of ample capacity.

What precautions must be observed in the case of an overflow?

The overflow pipe must be connected near the top of the tank, must be larger than the supply pipe, must be as simple and direct as possible to avoid the danger of obstruction, and may discharge in the same manner as already explained for blowoffs.

How are tanks supplied with water?

(a) From continuous pressure in the street main; (b) from intermittent pressure increased during the night and on holidays; (c) from a pump through a force main, and (d) from storage of roof water.

How is waste of water prevented in a tank supplied direct from the street main?

By the use of a ball cock to control the supply.

What construction is necessary for this purpose when the supply is pumped to the tank?

A telltale of some description. This may be (a) a small overflow discharging into the kitchen sink or at some other point conveniently observed from the pump; (b) a mechanical indicator, controlled by a float, may be easily designed to show on a graduated scale the amount of water in the tank, or (c) the float may be arranged to close an electrical circuit and cause a bell to be set ringing.

What conditions require the protection of safes under tanks?

The use of safes is not as general as formerly. In ordinary conditions, if a tank is well made and carefully

connected there is little reason for their use. If, however, the tank is so located above expensively decorated walls and ceilings, fine carpets and furniture that much damage would result from leakage, it may be desirable to provide a safe or floor with a lead lining, having a pipe waste. This safe waste should discharge at some point from which no foul or questionable air can return to pollute the air of the tank room. The use of a flap valve will assist in excluding the air.

What precaution should be taken in supplying a water closet from a house tank?

The supply to a water closet should invariably be made indirectly, that is, by the use of a flushing tank, into which the water from the storage tank is first discharged. This is necessary in order to avoid the possible danger of contamination of the stored water or of the air surrounding it.

What precautions should be taken to protect water stored in a tank from contamination?

Frequent attention must be given to the removal of any sediment which may collect in the bottom of the tank. The entrance of foreign substances must be prevented by a suitable cover. Provision must be made for the access of fresh air and the tank must if possible be located in a well ventilated room.

HOT WATER SUPPLY SYSTEM.

What are the essential parts of a hot water system?

The method of heating water in a hot water system is usually by means of a pipe coil or hollow casting placed in the fire box of the range or heater and connected to a cylindrical storage tank or so-called range boiler. There are also numerous appliances for heating water by a gas flame. The heating surface in a range is frequently called a water back or water front from its position in the firebox.

Would it be practicable to supply hot water direct from the water back without the use of a boiler?

While it would be theoretically possible to omit the boiler from the system, there would then be only a small quantity of very hot water stored in the water back. It would be possible to design a system of piping without the range boiler which would provide for the circulation of the water, but it would not be effective for lack of storage capacity.

What materials are commonly used for domestic hot water boilers?

The material of which boilers are usually made is galvanized sheet iron, although copper boilers, tinned on the inside, are used in some localities. The heads of the boilers are usually pressed into form out of sheet metal and the entire boiler is riveted together before being galvanized.

What are the characteristics of a good water back?

A cast iron water back should be designed so as to provide for frequent expansion and contraction and must be no thicker than is necesasry for the requisite strength. The inlet or cold water connection must be at the lowest point and so arranged as to provide for the removal of all the water and sediment when necessary. The outlet or hot water pipe must be placed at the highest point so that no air pockets will be formed and so that the warmed water may readily flow to the boiler, through a pipe graded upward. These conditions of easy drainage and ready outlet can be easily provided in a pipe coil.

What is the necessary relation as to position between the boiler and the water back?

In order to give storage to a quantity of warmed water it is necessary that a large portion of the boiler be placed above the level of the water back.

How should the cold water inlet pipe to the water back be arranged?

The inlet pipe to a water back should be so connected that water may pass in either directly from the service pipe or by a short connection from the bottom of the boiler. This result is accomplished by means of a cold water pipe or tube entering at the top of the boiler and open near the bottom. Water will flow from this pipe if water be drawn from any portion of the system. If no water is being drawn the colder water from the bottom of the boiler will pass into the water back and when heated rise to the upper portion of the boiler, thus insuring constant movement and an increased degree of heat.

Is there necessity for making the outlet pipe from the water back larger than the inlet?

Since the increase in volume of water warmed from 30° to 212° is less than one-twentieth, there is no necessity for increasing the size of the hot water pipe to allow for the expansion of water.

What causes may produce snapping or rumbling noises in the water back or boiler connections?

In a properly designed hot water system the operation of a very hot fire in the range may cause the characteristic sound due to boiling. Violent snapping or rumbling noises are occasioned by the collection of air in some portion of the system or by an obstruction to free circulation due to the presence of sediment or scales in the water back or pipes. These effects are very much aggravated if the boiler or pipe connections are not rigidly secured.

What is the purpose of a double boiler?

The purpose of having two boilers, one within the other, on a house supply system is to separate the supply to the fixtures which can use street pressure from that to the fixtures supplied from a tank to which the water must be pumped. This, of course, economizes pumping. A double boiler may also be used where it is desirable to use soft water from a cistern or other source of supply than the street main.

What is the usual arrangement of double boilers?

The boiler which supplies the lesser number of fixtures is usually placed within the second boiler and has itself no connections to the water back, the water in the inner boiler being heated, practically without the creation of

currents, by convection through its shell from the heated water in the outer boiler. It is important that a sediment cock be provided for the inner boiler.

What is the most frequent cause of water back explosions?

When steam accumulates in a water back by reason of the obstruction of the outlets the pressure is increased until it becomes sufficient to rupture the walls and explosion results.

What may be the result of drawing a large quantity of hot water when a hot fire is generating steam rapidly?

Under the conditions stated, the displacement of a large volume of hot water by cold water will cause the immediate condensation of any steam present in the boiler, the steam thereupon occupying only the space of the water from which it was made. This produces a vacuum within the boiler as the supply connections are not sufficient to refill this space with water at once. The effect of the atmospheric pressure on the shell of the boiler, acting with the vacuum within, produces a strong tendency to collapse. When copper boilers are not properly reinforced collapse sometimes occurs from this cause.

How does the street pressure influence the liability to collapse from this cause?

If the street pressure is heavy there is little opportunity for steam to occupy space within the boiler. If the pressure is light the water may be forced back into the mains and displaced by steam.

What objection is there to the use of a check valve to prevent displacement of water by its being forced back into the street mains?

The use of a check valve to prevent the return of water to the supply mains, while decreasing the danger of collapse, greatly increases the danger of explosion due to generation of steam pressure within the system.

What constructions may be used to prevent collapse or explosion?

The proper safeguard against collapse is a vacuum valve on the boiler. The relief of exceptional pressure should be provided for by the use of a safety valve or of an expansion pipe extended to the tank in the case of tank supply.

May damage result on a metered service by back pressure due to the generation of steam?

The rubber discs of meters are not designed to withstand the action of warm water.

Why is sediment collected in a boiler and water back?

The current of water in the service pipe prevents the deposition of the suspended matter which is found in the city water supply. The comparative stillness in the boiler allows the settling out of particles in suspension. This process is hastened in the water back itself by the action of the heat from the fire. The housewife often finds deposits in her teakettle, due to the same cause.

What is the purpose of a sediment cock?

A sediment cock is placed at the lowest point of a hot water connection in order to provide means of removing sediment from the boiler and pipes as well as to draw off the water when required.

THE DESIGN OF PIPE SYSTEMS.

Give the name, the use and size of the different pipes used in buildings.

The names of the plumbing pipes used in buildings are: (a) Drain; (b) Soil; (c) Waste; (d) Vent; (e) Water Supply.

The uses of these pipes are as follows: The drain pipe is the horizontal pipe into which the vertical lines throughout the building discharge. The soil pipe is any vertical or branch pipe through which water closets discharge, and is applied whether small fixtures empty into these pipes or not. The waste pipes are the vertical and branch pipes through which fixtures other than water closets discharge. The vent pipes are any air pipes the purpose of which is to prevent siphonage and back pressure on traps and insure a circulation of air in the piping system. This does not include a "local vent" pipe which has no connection with the plumbing pipes but only with the fixtures outside of the trap seals. Water supply pipes are such pipes as are used to bring the water supply into the building or to the various plumbing fixtures.

The sizes of these pipes in common use vary between limits as follows: Drain, 4 to 10 inches; soil, 4 to 6 inches. (Three-inch vertical soil pipes for the use of a single closet are sometimes used with good results.) Waste, 1¼ to 3 inches; vent, 1½ to 4 inches; water supply, ½ inch to 3 inches.

Of what materials are drain, soil and waste pipes made?

Drain pipes are made of cast iron or salt glazed vitrified earthenware.

Soil pipes are made of cast iron, galvanized wrought iron, lead and lead lined or enameled cast iron. In rare cases they are constructed of brass.

Waste pipes are made of lead, cast iron, galvanized wrought iron, lead lined cast or wrought iron, enameled cast iron or brass.

Why is cast iron used exclusively inside the house line?

Cast iron is used exclusively in the Eastern cities for house drains because of its security and durability. The joints of earthenware pipe are often insecure and the pipe itself is rarely straight and of uniform smooth bore. It is also liable to fracture by reason of its brittleness.*

State some of the chief sanitary requirements for soil and drain pipes?

The chief sanitary requirements for soil and drain pipes are: (a) An impermeable, non-porous structure; (b) smooth, uniform and non-corrosive interior surface; (c) few and durable joints; (d) a certain amount of elasticity, with sufficient strength to maintain grade and alignment.

Is there any disadvantage in having drain and soil pipe of large size, and why?

The principal disadvantages in the use of drain and soil pipes of unnecessarily large sizes are: (a) The liability to obstruction. (b) The increased area of intetior fouling surface and the larger volume of contained foul air. (c) Unnecessary expense due to use of larger sizes.

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*A complete discussion of the advantages of cast iron over tile for house drains is to be found in the issues of "Domestic Engineering" for May 27, June 3 and 10, 1905, and in other numbers of various later dates to March 14, 1906.

What are sandholes and flaws?

Sandholes and flaws are imperfections which occur in castings. Sandholes are spaces into which the melted metal failed to flow because of the presence of a lump of molding sand, or other obstruction, usually coated with sand, and often removable when the casting is cleaned. Flaws are defects in castings where the form is preserved, but the metal is not continuous, thus causing a seam or crack.

What is meant by corrosion?

Corrosion is a chemical process by which a metal is eaten away while compound substances are being formed. The disintegration of iron while iron oxide (rust) is being formed, constitutes a common example. The pitting of the outside of lead pipe when spattered with lime mortar is also frequently observed.

How is cast iron pipe prepared before it is used?

Cast iron pipe is prepared for use by dipping into a hot solution of coal-tar pitch or asphaltum, thus making smooth the inside and protecting the outside against rust. In Canadian cities linseed oil is the only coating allowed to be used. In some American cities, notably Washington, D. C., no coating whatever is allowed until the pipe has been tested in place and approved by the inspector.

In what lengths does cast iron pipe come?

Cast iron soil pipe is manufactured in lengths of five feet in addition to the length of the hub.

Which is best, standard or extra heavy pipe, and why?

Extra heavy cast iron pipe is preferable to standard pipe because of the greater thickness of the walls, affording

greater security against flaws and sand holes, and the increased strength of the hubs, which strength is required to withstand the pressure caused by caulking the lead joints.

What should be the thickness of 2, 3 and 4 inch standard cast iron pipe, and also of extra heavy?

The thickness of 2, 3 and 4 inch standard cast iron pipe is about ⅛ inch. The thickness of extra heavy pipe is about ¼ inch.

What should be the thickness of 5 and 6 inch standard cast iron pipe, and also of extra heavy?

The thickness of 5 and 6 inch standard cast iron pipe is 3-16 inch and of extra heavy 5-16 inch.

Give the weight per foot of 2, 3, 4, 5 and 6 inch standard cast iron pipe, in five feet lengths, with hub and spigot, and also of extra heavy.

The weights of standard and extra heavy pipe are:

	Standard.	Extra heavy.
2 inch	3½	5½
3 inch	4½	9½
4 inch	6½	13
5 inch	8½	17
6 inch	10½	20

What is an important consideration in the strength of cast iron pipe?

Even if the weight of cast iron pipe conforms to the above tables, it is most important that the thicknesses of the walls be uniform throughout.

Is there any way of testing the uniform thickness of cast iron pipe?

The presence of marked differences in the thickness of the walls and bad flaws in the structure of cast iron pipe

can be detected by a difference in sound when struck by a hammer.

Which end of a pipe should be placed uppermost, and why?

The socket end of the pipe should invariably be the end at which the flow of sewage enters. In the case of vertical pipes this should be done in order to prevent the dripping of sewage from joints which are not tight as well as to facilitate the pouring of the lead.

Describe how leaded joints between cast iron pipes should be calked, and why this is necessary.

After having carefully yarned the joint by forcing a strand of picked oakum, moderately twisted, into the hub, with a yarning tool and then having filled the joint to overflowing with molten pig lead by one continuous pouring, the joint should be caulked uniformly with a steel caulking tool. The purpose of the caulking is to expand the lead which has contracted somewhat in cooling so that it will be solid and uniform, occupying all the interstices of the surrounding cast iron on hub and spigot. The caulking must be done uniformly so that the pressure will be exerted equally on all points of the hub, and should be begun at the point difficult to get at, which might otherwise be slighted. The pipe should be circled once by the tool lightly tapped, the force of the blows being increased on the second and subsequent tamping. A cold chisel or other tapering tool should not be used as it greatly increases the danger of cracking the hub through over-pressure.

What is the least depth the ring of lead should have and how much lead should be allowed to a joint?

In order that the pressure exerted may be distributed over as large an area as possible, the depth of lead in a finished joint for 4-inch pipe should not be less than three-quarters of an inch and should preferably be somewhat deeper. The amount of lead required for a strong joint may be estimated by allowing for every joint three-quarters of a pound for each inch in the diameter of the pipe.

How can pipes be caulked when in a recess of the wall?

Wall recesses for pipe work must be large enough to afford ample working space on either side of the pipe. Some advantage may be gained by the use of offset caulking tools. If a stack has no double fittings it can be partly revolved so as to afford opportunity to make the upper joints before the lowest joint is poured.

Where should a rust joint be made?

A rust joint may be used outside of the fixture traps under conditions where steam or very hot water is to be carried through cast iron pipes but should not be used on any closed portion of a house drainage system.

How are rust joints made?

The material for rust joints consists of a mixture of five pounds of iron borings, free from oil or grease, and one ounce each of sal ammoniac and flowers of sulphur. These ingredients are mixed dry and then wet to a thick paste which is placed in the pipe hub and caulked like lead.

Why are putty, mortar and cement joints objectionable?

The principal objections to the use of putty, mortar and cement as materials for pipe joints are the practical difficulty in making such joints gas tight and the inflexibility of these materials when hardened.

How should the connection between two earthenware pipes be made?

The various steps to be followed in making a joint of this nature consist in: (a) Wetting the ends of the pipes with water. (b) Placing the spigot end into the hub of the last laid pipe so as to have an equal space all around for the joint material. (c) Placing in the space between hub and spigot a rope of loosely-twisted picked oakum and tamping same as far as it will go. (d) Filling remainder of joint space with mortar composed of one part sand and one part of strong cement, paying especial attention to filling the under side of the joint completely. (e) Strengthening the joint by building up a reinforcing ring of cement concrete to a thickness of two or three inches. (f) The inside of the pipe must then be examined and any cement or oakum which has entered can be removed with a proper tool for this purpose.

What general considerations govern the best design and running of soil, waste and vent pipes?

(a) Simplicity and directness. The lines must be as few in number as will adequately serve the fixtures and must be run as directly as possible to them. This involves, wherever possible, the placing of the fixtures on an upper floor directly above those on a lower floor, and also the grouping of fixtures in adjoining rooms on opposite side of the common partition.

(b) The avoidance of unnecessary offsets and bends, especially in vertical lines. More careful study of the location of pipes often will render unnecessary the use of offsets or bends to escape obstructions.

(c) Accessibility. Good design does not permit the location of any plumbing pipe behind a plastered surface or under a floor in such a manner that its course through the building cannot readily be determined, or so that the pipe cannot be easily reached for inspection. It is especially necessary that joints be not concealed within tne floors or walls.

(d) Size. The avoidance of larger pipes than necessary for the required use is a fundamental principle of design. From the use of too large sizes in soil and waste pipes results inadequate flush and larger fouling surface, while the increased size complicates the problems of location.

(e) Location. In order to afford adequate protection against cold all pipes should be placed entirely within the walls of the building.

(f) Continuity of bore. Where the material of the pipe changes, as from lead to cast iron, or from iron to tile or its diameter is increased or decreased, care is necessary in designing the connection to insure smoothness of the bore. There will otherwise result obstructions to the flow of air or water and waste spaces in which foul matters will collect.

(g) Gradient. The portions of the plumbing system which are not vertical should be given as steep and uniform a slope as conditions will permit. In soil and waste pipes the purpose of quick discharge of wastes will thus be accomplished and in vent pipes the movement of the air will be accelerated.

(h) Supports. Horizontal lines should be supported at frequent intervals either from beneath by means of masonry piers or iron posts or from above by adequate hangers, or, if close to the wall, by means of heavy brackets. Pipe hooks and loops of chains are unsuitable for this purpose.

Vertical pipes should invariably be supported from the bottom on a fitting having a strong footrest and in addition on pipe rests or clamps set under the hubs or couplings at least as often as every story of the building. If wood blocks or rests are used care must be observed that they are well fitted and firmly fixed.

(i) Cleanouts. It is practicable to design plumbing so that an obstruction occurring in any portion of the system may be within reasonable distance of a cleanout opening. The increase in cost due to the insertion of such facilities at suitable points may be more than saved to the owner in the avoidance of the necessity of cutting into a continuous pipe.

What should govern the choice of fittings for soil, waste and vent pipes?

The fittings used with any pipe must correspond closely with the pipe itself. Bends and branches should have long radii instead of short curves. For wrought iron waste and soil pipes carefully recessed fittings should be used, against the shoulders of which the pipe ends abut when screwed up.

Certain fittings should be prohibited for particular uses. A double Y with its branches in the same plane as the main line should not be used on pipe with slight gradient as sewage is likely to back up in the branch having the least use. For the same reason double sanitary T fittings

are objectionable. A plain T fitting should not be used for any soil or waste branch.

How do you define the expression "dead-end" applied to a drain or soil pipe?

The expression "dead-end" applied to a drain or soil pipe, means any portion of the pipe through which sewage does not flow nor air circulate.

Why are these dead-ends dangerous?

Dead-ends are dangerous because of the accumulations of stagnant gases which may be generated in them, and may escape through some unusual condition of pressure or operation in the system. Pipes leading from disconnected, disused or unventilated fixtures, are in effect dead-ends, and are a source of danger when allowed to remain as part of the piping system.

How large should the soil pipe be from the highest fixture to the roof?

The soil pipe should in general be extended above the highest fixture through the roof, of the same size that it has at the fixture branch, in order that the free circulation of air may not be checked in any part of the system by reason of decreased air capacity of the pipe.

About how much would a stack of soil pipe about fifty feet high be likely to expand and contract, and should any provision be made for such expansion and contraction?

A stack of soil pipe fifty feet high might under extreme conditions vary in temperature from 10 degrees below zero to 90 degrees above. The co-efficient of expansion of cast iron being 1-162000 for one degree, multiplied by 100=1-1620th of lineal expansion. If this be multiplied by the assumed length of fifty feet the product will be

3-100th of a foot or approximately ⅜ of an inch. This may be considered the greatest possible expansion. As it is not likely that all the ten or more joints would have the spigot resting solidly against the bell the top of the stack would move somewhat less than this, some of the expansion being taken up by the slackness of such joints.

Why is lead objectionable for soil pipes?

Lead as a material for soil pipes is objectionable because of its weight, making it liable to sag, and because of its softness, making it liable to be punctured by nails or gnawed by rats. It is also subject to corrosion if the gases of decomposition are confined in it, and it does not completely contract after being expanded by heat.

Are lead pipes liable to injury from fresh mortar?

Fresh mortar should never be allowed to come into contact with lead pipe by reason of the injury to the pipes by the formation of calcium carbonate and other corrosive salts.

How can pipes in a building be tested?

The pipes in a plumbing system in a new building are usually tested either by a water test or an air test. Every plumbing system should be tested after the fixtures are set by a smoke and pressure test. The testing of old plumbing is usually performed by the smoke test or the peppermint test.

What is the best test for plumbing pipes?

The best test, because most uniform and most universally applicable, consists in pumping air into the closed system of piping until a sufficient pressure (not less than three pounds per square inch) is indicated on a mercury gauge, and noting that this pressure is maintained on the

gauge for at least five minutes. Under favorable conditions the system of piping having its lower end closed may be filled with water, the upper surface of which may be observed to note whether it maintains a constant level.

THE MAIN DRAIN.

What fall per foot should a horizontal drain pipe have?

The principal conditions which govern the flow of sewage through a pipe without danger of obstruction are three: (a) The diameter of the drain. (b) The fall or slope. (c) The depth of flow. The smaller the drain the deeper the flow. The greater the slope the more rapid the flow. It has been shown by repeated experiments that a velocity of flow less than about three and one-half feet per second will not carry along the solid matters with the water. At least this velocity is attained by giving a slope of 1 in 40 to a 4-inch pipe; 1 in 50 to a 5-inch pipe, etc. This rule, known as Beardmore's rule, may safely be extended to 10 or 12-inch pipe. The slope of one-quarter inch per foot adopted by experienced plumbers and prescribed in many regulations, is slightly in excess of this requirement. It is an exceedingly common error to use drain pipe of too large size, thus losing the advantage of greater depth of flow in smaller sizes. A 4-inch pipe one-quarter full would have a velocity of 198 feet per minute, while if two-thirds fall the velocity would be 278 feet per minute for the same gradient.

Is it usual to make horizontal drain pipes larger than the vertical soil pipes?

It is a common practice to make the horizontal drain pipe five or six inches in diameter for the supposed reason that an increased size is necessary to provide for the roof

and surface drainage. The studies made in connection with separate systems of sewers have shown that the efficiency of a 4-inch drain for most premises cannot be questioned. The smallest practicable size should be used for reasons which already have been stated.

Why should the hole in the wall through which a drain pipe passes be larger than the pipe?

The hole through which a drain pipe passes should be larger than the pipe, especially above the pipe, in order to allow for movement if the pipe expands and to insure freedom from pressure due to the weight of the wall even if settlement occurs.

How should rain conductors be connected with a main drain?

Rain conductors may be connected with the main drain either by a direct connection or indirectly through a receiving basin. If directly connected each rain conductor should be provided with a proper S or P trap having a clean-out, and so located as to be readily accessible, and not exposed to frost. If indirectly connected the basin must be water-tight, must either be a self-constituted trap or be provided with an outside trap. An important disadvantage of the connection through a basin is that the scouring effect of the rain water flow upon the drain is lost. It is sometimes desirable where the top of the conductor is above window and ventilator openings and where the material is cast or wrought iron to omit the trap.

How should area and yard drains be connected with the main drain?

Area and yard drains may be connected with the main drain by the same types of construction used for rain

conductors, except that greater care must be taken to provide traps which do not readily lose their seals by evaporation. The system of drainage should be designed with a view to making the dead-end branches to these openings as short as possible. If a basin is used these connections may advantageously be grouped to discharge into it.

THE MAIN TRAP.

What is the object of placing a trap upon the main house drain?

The theoretical purpose of a trap upon a main house drain is to disconnect the house plumbing system from the main sewer system. It often fails to perform this function because of accumulated air pressure in the public sewers. It also serves to obstruct the free flow of sewage from the house system and offers a point of lodgment for obstructive material which otherwise would freely pass into the public sewer.

What is the best form of main trap for a house drain?

The best and most usual form of main trap for a house drain is that of the running trap. This is usually made with symmetrical inlet and outlet legs, but could be much improved by modifying its form so as to provide a vertical inlet and an outlet with a more gradual rise.

How deep a water seal should a main trap have?

The depth of water seal in the main trap should never be less than two inches, and if the trap is well designed a depth of three inches is desirable.

Why is a brick or stone box having a partition wall, and known as a mason's trap, objectionable on a house drain?

A mason's trap is objectionable because it contains a large quantity of sewage, has a large amount of rough

and absorptive surface and is difficult to construct so as to be free from danger of leakage.

What are the advantages and disadvantages of a flap valve as a part of the main trap?

If a flap valve is well designed and properly seated, it offers a sure resistance to the entrance of sewer air. If, as is often the case, the flap and seat become foul, the flap does not return to its seat in such a way as to be gas tight.

If a main trap is desirable upon a house drain, would not two traps be better?

Inasmuch as the efficiency of the main trap to resist the entrance of sewer air depends only upon the depth of its seal, the combined effect of two traps can better be secured by the single trap with its depth of seal equal to that of both. The disadvantages resulting from the use of two traps are the uncertain compression and lack of air circulation in the space between them, and an increased liability to obstruction due to the loss of velocity of flow of the sewage.

What causes a pressure on the sewer side of the main trap?

The most important cause of pressure on the sewer side of the main trap is the rapid compression of air in the sewer by the entrance of storm water. The same effect, in a less degree, may be produced in a sewer with few ventilation openings by the rising of tide-water in the closed outlet end.

If a house drain empties into a stream or discharges on the surface of the ground and has no connection with a sewer or cesspool, is a trap useful?

A house drain having an open end does not require a trap near such end, but should invariably be provided with a main trap and air inlet just outside of the foundation wall in order to insure the admission of air to the piping system.

THE AIR INLET.

What is the object of providing a pipe extending from the outer air to a point just inside the main trap?

A pipe from the outer air to the main drain immediately back of the trap is provided to allow the entrance of the outer air for circulation to the lower portion of the plumbing system or to provide relief for air pressure which may accumulate at this point.

What is the proper size for a fresh air inlet?

The proper size for a fresh air inlet on a 4-inch main drain is four inches, although this size is not required except for its probable freedom from the accumulation of obstructions. For larger drains some increase in size is required.

Why should the fresh air inlet be connected to the drain as near as possible to the trap on the house side?

The connection of the fresh air inlet should be made as near as practicable to the trap in order to insure the ventilation of the entire house drain and relieve pressure on the house side of the main trap.

Why does air enter through the inlet and pass out at the top of the vent pipe?

Air enters at the fresh air inlet and passes out at the top of the vent pipe on account of the tendency of warm air to rise. As the outer air passes through the drain it becomes somewhat warmed, and as it passes through the

soil and vent pipes, it becomes still more heated. As it is warmed it expands, which makes it lighter than the outside air and causes an upward current which in turn draws in a further supply of air through the inlet. The action is similar to the action of a cork released at the bottom of a vessel of water.

Can a downward movement of air through the soil pipe affect the upward current?

The downward movement of air and water through the soil pipe caused by the discharge of a fixture sometimes produces a stoppage or reversal of the upward current of the air, which may cause sewer odors to escape from the inlet. This may be in a measure obviated by having the main vent pipe connected near the foot of the soil pipe.

TRAPS.

If a main trap has been provided on the house drain is it necessary also to trap all fixtures?

In order to prevent the entrance into the house of the foul gases resulting from decomposition in the plumbing pipes it is necessary to provide a trap on each fixture waste, even though a trap has been provided on the main drain to keep out the air from the public sewer.

How do you define the term trap as used in plumbing?

A trap is a fitting or a portion of the waste pipe depressed so as to retain a body of liquid, usually water, in such manner or to prevent passage of air from within the waste pipes.

How is a trap sealed?

A trap is sealed by the fluid, usually water, which it contains, through which the gases on the sewer side of the trap cannot pass.

Does it serve its purpose effectually?

If a trap is so formed as to be self-cleansing, to interpose a sufficient depth of water and has its contents frequently renewed it serves its purpose in an effectual manner.

How is the depth of water seal measured?

The depth of water seal is the vertical distance between the surface of the water at rest and the highest point in the lowest cross section of the trap.

Does a trap containing a large body of water with a shallow seal afford proper resistance to back pressure?

Since the resistance offered to the passage of sewer air through a trap depends solely upon the depth of water seal a trap containing a large body of water, but having a shallow seal does not afford adequate resistance to back pressure.

Is there any objection to a trap having a deep seal?

A trap having an unnecessarily deep seal is liable to become obstructed because the presence of a large body of standing water checks the velocity of flow of the sewage through the trap.

Will the water in a trap absorb gas and emit it again?

The water constituting a trap seal will absorb minute quantities of gas when the pressure is exceptional. Dr. Carmichael, of Glasgow, has shown that no danger is to be apprehended from this source, as only small quantities of gas are emitted after absorption.

How is this difficulty overcome?

By affording ample circulation of air by means of trap ventilation and by the frequent renewal of the water in the traps by the discharge of fixtures.

What are the four methods by which the water seal of a trap may be lost?

(a) Siphonage caused by the rarefaction of the air in the waste pipe, either through the discharge of the fixture itself or by the discharge of some other fixture.

(b) Back pressure; the compression of the air within the waste pipe until the added pressure exceeds that of the column of water which forms the trap seal, so that sewer air is forced through into the room.

(c) The slow loss through evaporation of the water in the trap seal. This loss is hastened by the currents of air caused by trap ventilation.

(d) The action of capillarity through the presence of strands of rag or fibre hanging over the trap weir, through which the water rises and escapes, by evaporation, or by dripping into the waste pipe.

What are the essentials of a safe trap?

A trap to be safe must be of such form that when the waste water is flowing through it no channel will be formed for the escape of sewer air.

The depth of the trap seal must be sufficient to be maintained against pressure from the sewer side, against siphonage and against loss by evaporation.

The trap must be of such shape that it is effectually scoured by the passage of waste water through it. The design must be such as to present the least possible amount of fouling surface.

What is the purpose of mechanical traps and what is the objection to them?

A mechanical trap is one which has a flap valve, a ball or other moving part designed to oppose an additional obstacle to the entrance of sewer air. The principal objection to this type of trap is that it is not thoroughly cleansed by the passage through it of the waste water.

What are the principal forms of non-mechanical traps?

(a) The round pipe traps, which were originally formed by bending ordinary lead waste pipe, consist of the running trap, having two horizontal ends; the S trap, having a vertical inlet and outlet; the P trap, having a vertical inlet and horizontal outlet, and various modifica-

tions of these forms, known as the three-quarter S, the bag trap, the Q trap and the pigtail trap.

(b) The bottle trap has an inlet at the top, an inner tube extending nearly to the bottom, and an outlet at the side near the top.

(c) The drum trap has an inlet on the side, near the bottom, and an outlet near the top.

(d) The bell trap has a standing waste, the end of which is covered by an inverted cup, which dips into the sealing liquid.

(e) Beside those already mentioned there are many forms, made of iron or brass, having partitions cast within them, the position of which is not ascertainable when the trap is connected. Many of these are unreliable owing to defects incidental to the process of manufacture.

Is it a sanitary necessity that each waste outlet of a compound fixture be provided with its separate trap?

Some plumbing ordinances allow the connection to a single trap of two or more outlets from a set of basins, washtrays or a compound fixture. Little objection arises to this construction if the pipes are short, so that the interior fouling surface above the trap is small. Nuisance results if this practice is extended, so that the decomposition of wastes in pipes of considerable length contaminates the air of the room.

VENTILATION PIPES.

What is the purpose of providing means for the ventilation of a plumbing system?

In order to dilute the gases formed by decomposition of sewage and to carry them out it is necessary to provide for the entrance of fresh air into the pipes and its circulation through them.

What is the use of making a connection between the main vent pipe and a fixture trap?

The purpose of supplying air to a fixture trap is twofold. First, to forestall the effects of siphonage and back pressure upon the water seal of the trap, and, second, to secure a circulation of air through the waste pipe.

Describe the process of trap siphonage and how this is prevented by back venting.

(a) If a fixture has a long, nearly horizontal waste branch a rapid outflow of the water from the trap may carry with it the air contained in the pipe and produce a partial vacuum. To restore equilibrium, air may enter through the trap and perhaps carry with it into the waste most of the water, so that not enough remains to fully seal the trap. If the trap be vented by an air pipe near its crown air will come into the waste through the vent pipe rather than through the water in the trap and so equalize the pressures.

(b) A second case in which back pressure and siphonage are liable to occur is where the trap seal may be en-

dangered by the discharge of a higher fixture connected into the same vertical waste line. When the water flowing down the vertical stack nearly or quite fills its bore the air in front of it is compressed to a greater or less degree. This compression may be sufficient to disturb the seal of the trap and possibly force sewer air through it unless the branch waste is of such length as to prevent this by acting as an air cushion. If means of escape be provided for the compressed air through a vent pipe to the trap this effect will be prevented.

When the waste water descends in the stack a partial vacuum will exist behind it. When this vacuum extends to the branch air will pass from the vent through the waste line and restore equilibrium of pressure, thus preventing any bad effect upon the seal of the trap.

If the efficiency of a given trap to resist siphonage is assumed, does reason still exist for providing a back vent connection?

Certain types of traps have been designed which will not suffer loss of the water seal even if exposed to the operation of an almost complete vacuum. If such a trap is used on a long waste branch provision should be made by the use of a vent pipe to remove the gases due to decomposition.

Is it practicable to dispense with trap vents where a single fixture is installed close to a vertical line?

It is a safe practice where a fixture is near a vertical stack and its trap is not liable to be affected by the discharge of other fixtures into the same stack, to allow its trap to remain unvented. The extreme distance from the stack allowed by any regulation is five feet, which is probably too great for entire safety. This construction is

less desirable if an S trap or three-quarter S is used than with a P trap. The same construction may safely be applied to two fixtures the wastes from which enter the stack at the same level.

Does good design allow the omission of a trap vent for the highest fixture discharging into a stack?

It is considered good practice to omit the vent connection from the highest water closet discharging into a stack to which other fixture wastes connect if the fixture in question is not distant more than two feet from the stack.

May the venting of individual traps be dispensed with where fixtures are grouped?

Where a number of fixtures are placed in line so as to discharge with short wastes into one horizontal pipe the circulation of air may be effected by providing a vertical extension of the main waste line opening to the outer air or reconnected to the stack above the fixtures. This construction is not applicable if higher fixture wastes enter the same stack. It may, however, be applied to like groups of fixtures on successive floors of a building, the construction in this case requiring the extension of the main waste line on each floor to a point of connection with the main vent above the fixtures on that floor, and the reconnection of the main vent to the stack above the highest group.

Where should vent pipes terminate?

Every soil and vent pipe should have its open end at such a height (not less than two feet) above the highest part of near-by roofs as to insure free circulation of air about it and avoid eddying or cross currents. Every such end should be sufficiently distant (not less than ten feet)

from adjacent windows, doors, ventilators or chimney tops to insure a sufficient dilution of sewer air under all circumstances so that its presence could not be detected by ordinary means at the nearest opening.

Should the exposed ends of soil and vent pipes be provided with any means of protection?

The primary function of a soil and vent pipe to afford free passage of air circulation into and out of the plumbing system should not be interfered with except by the use of a wire basket or cage which does not materially diminish the area of its cross section. The use of cowls or caps is inadvisable as such appliances are uncertain in their action and especially liable to be closed by the formation of frost at low temperatures. Every such pipe end should be so located as to be out of the reach of mischievous children.

EFFECTS OF FREEZING.

What is the physical principle upon which depends the damage to pipes and appliances from freezing?

The physical principle by reason of which damage from freezing occurs is the fact that water in passing from its liquid to a solid state immediately expands about one-tenth in volume. This expansive force exerts a very great pressure upon all sides of a containing vessel.

How does this force burst iron and lead pipes?

Although some opportunity is afforded for expansion within the pipe, this advantage is soon overcome by the friction of the ice upon the pipe walls and the expansive force is thus concentrated at one point. The effect upon iron pipes is to cause the pipe to split lengthwise. In the case of lead pipes the metal may expand sufficiently to allow space for the contained ice. When thawed out the pipe does not contract to its original form and thickness and if the process of freezing is repeated, the pipe will soon burst.

How should pipes be located so as to avoid danger from freezing?

In order to prevent freezing, pipes buried underground, should if possible, be placed below the depth to which frost ever reaches. In a cellar they should be placed on a ceiling wherever possible and away from window and door openings. Rising lines should be placed in partitions rather than in outside walls. For this reason

fixtures located on a cold wall may preferably be supplied from the floor rather than from the wall.

What constructive precautions may be observed to prevent freezing?

The most important provision against freezing is that every portion of the supply line be so graded that the water can be entirely drained from it through the stop and waste cock in the cellar. It is practicable to lessen the damage from freezing by providing at suitable points air chambers in which the air may be compressed so as to cushion the expansive effect of water when freezing. A third means of protecting pipes against freezing is by the use of suitable coverings, such as felt, paper, asbestos, etc. The use of boxes filled with sawdust or any other material which may become saturated and subject to decay is objectionable.

If water is to be allowed to run constantly to prevent freezing what precautions should be observed?

It is not necessary, as is sometimes believed, that a strong flow of water must take place in order to prevent freezing in the pipe. A small stream trickling through the faucet gives all the advantage to be derived from a constant change of the water at a given point in the pipe and even this causes a very much larger total waste of water than is popularly appreciated. The adoption of a policy of basing water rate in each case upon the amount of water ordinarily used as measured by meters, would result in a great saving in the amount of water consumed and a marked advantage to the public water funds.

What methods may be most readily applied to the thawing of frozen water pipes?

The use of a plumbers' torch, or an extension burner from the gas jet offers a ready means of applying a constant source of heat where the pipes are exposed and fire danger does not occur from this method. Heated irons or cloths wet with hot water may be used where the freezing is limited to a short length of pipe. The application of a current of electricity for thawing underground pipes has recently been tried and is a method which seems to have proven very successful. Where electricity is used from street lighting or trolley lines, the voltage must be considerably reduced. By the use of block tin tubes, steam and hot water may be conducted to the point of obstruction. If steam is used for this purpose it is generated in a closed tank which must be provided with a safety valve to insure against the danger of explosion. If hot water is used it may be pumped to the point where the stoppage occurs by means of a hand force pump.

PUMPS.

Upon what physical principle does the operation of a common pump depend?

A common pump depends for its operation upon a lack of equilibrium in the air pressures upon the surface of the water in the well and in the pump chamber.

What are the essential parts of a common pump?

The essential parts of a common pump are:

(1) A cylinder, at the foot of which is a valve opening upward.

(2) A piston containing a valve and fitted to the cylinder. This valve also opens upwards.

(3) A lever or other means of moving the piston.

Describe the operation of a common pump.

The cylinder being filled with water, which is held in place by the closed foot valve, the piston is lowered through the cylinder and a portion of the water passes through the piston valve to the upper part of the cylinder. The piston having reached the end of the down stroke begins to move upward and the water above it flows out of the spout. As the piston rises a partial vacuum is formed in the cylinder below it. When the difference in pressure between the air in the cylinder and the outer air is sufficient to overcome the weight of the water column from the pump to the level of the water in the well the water will begin to rise, open the valve and flow into the cylinder.

What is the greatest distance below the pump from which water may be raised by a simple pump?

As the atmospheric pressure of 14.75 pounds per square inch will balance a column of water 34.03 feet high a pump theoretically will raise water to that height. In practice, on account of the losses due to friction and the weight of the valve, a pump will lift water only about 28 feet.

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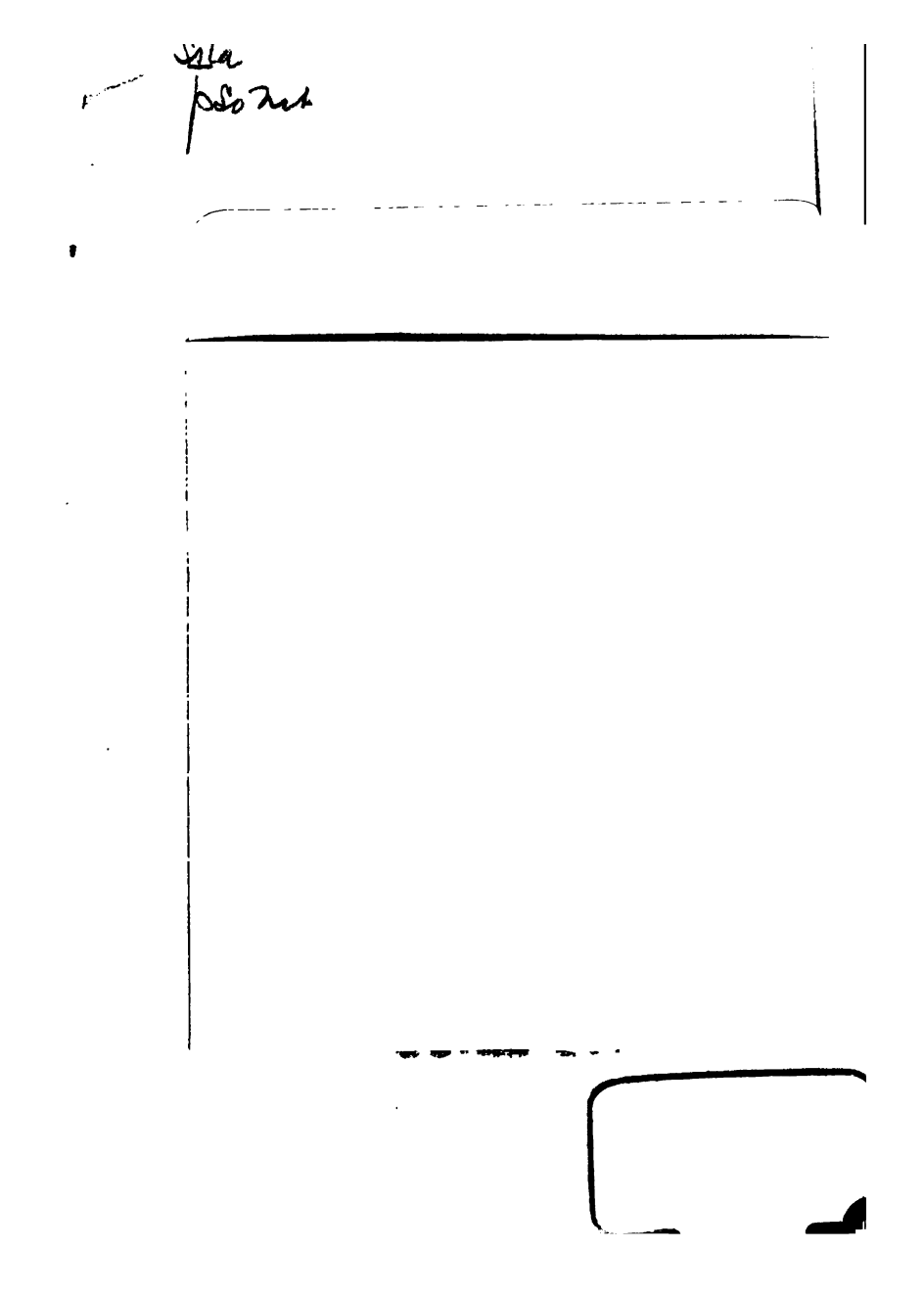
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